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MATHEMATICS.—*Account of researches in the algebra of physics.*[1] III. A. MACFARLANE.

Differentiation in the quaternion analysis. Read before the Royal Irish Academy, June 25, 1900. Proc. (3) VI: no. 2. The object of the paper was stated as follows: There are two places in the *Elements of Quaternions* where further investigation seems desirable. The quaternion analysis is intended to be applicable to space of three dimensions, but at these two places Hamilton restricts the analysis to the plane. The first place is in the treatment of logarithms. He says in Art. 316:

> In the present theory of diplanar quaternions we cannot expect to find that the sum of the logarithms of any two proposed factors shall be generally equal to the logarithm of the product; but for the simpler and earlier case of complanar quaternions that algebraic property may be considered to exist with due modification for multiplicity of value.

The other place is in the treatment of differentiation. He says in Art. 333.

> The functions of quaternions, which have been lately differentiated, may be said to be of algebraic form; the following are a few examples of differentials of what may be called, by contrast, transcendental functions of quaternions; the condition of complanarity being, however, here supposed to be satisfied, in order that the expressions may not become too complex.

I then proceeded to show that the source of the difficulty in both cases was one and the same, namely, the erroneous use of

[1] Read before the Philosophical Society of Washington, April 20, 1912. See this Journal 2: 331–337 and 363–372. 1912.

conjugate powers instead of the complete powers. For example, in the case of the square, the use of

$$A^2 + AB + BA + B^2$$

which gives merely the square of the resultant, instead of

$$A^2 + 2AB + B^2$$

which is the complete square of the complex $A + B$.

Hyperbolic quaternions. Read before the Royal Society of Edinburgh, July 16, 1900. Proc. **23**: pp. 169–180. In this paper the hyperbolic analogue to the spherical quaternion was further considered, the surface corresponding to the sphere being the equilateral hyperboloid comprising all three sheets. Lord Kelvin was in the chair; from his well known antipathy to the spherical quaternion it required some courage to attempt the elucidation of the hyperbolic one, even with the aid of models made of wire.

Application of space-analysis to curvilinear coördinates. Deuxième congrès international des mathématiciens, pp. 305–311. Paris, 1900. An expression is given for ∇ in the case of equilateral-hyperboloid coördinates. Let R denote a vector to the positive double sheet of such a surface; then $R = r\rho_1$, where r denotes the hyperbolic modulus and ρ_1 the hyperbolic unit.

Now $\rho_1 = \cosh\theta \cdot h + i \sinh\theta\,(\cos\varphi \cdot j + \sin\varphi \cdot k)$;

$$\rho_2 = \frac{\partial\rho_1}{\partial\theta} = \sinh\theta \cdot h + i\cosh\theta\,(\cos\varphi \cdot j + \sin\varphi \cdot k);$$

and $\rho_3 = -\sin\varphi \cdot j + \cos\varphi \cdot k$;

hence $\nabla = \frac{\partial}{\partial r} / \rho + \frac{\partial}{\partial\theta} / r\rho_2 + \frac{\partial}{\partial\varphi} / r\dot{i} \sinh\theta \cdot \rho_3$.

On the square of Hamilton's delta. Atti del IV congresso internazionale dei matematici, **3**: pp. 153–157. Roma, 1908. The common way of forming the square of the sum of three successive vectors gives merely the scalar part of the complete square. Does, it was asked, a similar distinction hold in forming the square of Hamilton's operator ∇, which is well-known to be a kind of symbolic vector? In the case of rectangular coördinates

$$\nabla = \frac{\partial}{\partial x} / h + \frac{\partial}{\partial y} / j + \frac{\partial}{\partial z} / k;$$

and ∇^2 is said to be

$$\frac{\partial^2}{\partial x^2}/h^2 + \frac{\partial^2}{\partial y^2}/j + \frac{\partial^2}{\partial z^2}/k^2,$$

from which is derived by reduction

$$\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}.$$

But in the multiplication the vector part has been cancelled out due to an artificial order of the factors, whereas the real order is a cyclical order of the terms. When the parts cancelled are restored, the square has the additional term

$$2\left\{\frac{\partial^2}{\partial x \partial y}/hj + \frac{\partial^2}{\partial y \partial z}/jk + \frac{\partial^2}{\partial z \partial x}/kh\right\}.$$

It was shown also in the case of polar coördinates, that the restoration of the cancelled terms gave the complete square.

Unification and development of the principles of the algebra of space. Bulletin of the Quaternion Association. October, 1910, pp. 41–92. As regards unification the following position is held:

> We have before us three forms of space-analysis: the *scalar*, founded by Descartes, which makes use of axes, but provides no explicit notation for directed quantities whether line or angle; the *quaternionic*, founded by Hamilton, which is characterized by a notation for versors or angles in space; the *vectorial*, founded by Grassmann, which is built on vector-units and compound units derived from them. For the past half century the masters of these several forms have been engaged in a triangular fight: much has been written on vectors *versus* quaternions; and we have heard of a thirty years' war between one who could bend the bow of Hamilton and one equally skilled in the more ancient weapon of Descartes. It will surely be admitted that each branch contains part of the truth; it is therefore highly probable that no one of them contains the whole truth, and that each has a part of the truth which the others have not. It has for long seemed to me that what is wanted is an analysis which will harmonize all three, and present itself as the space-generalization of algebra. As to this conception of the oneness of the algebra of space, I may quote Sylvester's declaration that he would as soon acknowledge a plurality of gods as a plurality of algebras. Likewise, Gibbs at the close of his address to the Mathematics Section of the American Association, said we begin with multiple algebras and end with multiple algebra.

Quaternions and vector-analysis are reconciled and unified by the complementary principles

$$(i\alpha)\ (i\beta) = -\cos\alpha\beta - \sin\alpha\beta\ .\ i\ [\alpha\beta]$$

and

$$\alpha\beta = \cos\alpha\beta + \sin\alpha\beta\ .\ i\ [\alpha\beta].$$

Both are unified with algebra and the Cartesian analysis by the development which is given of the line complex of vectors, and the cyclic complex of vectors.

Line complex of vectors. Let A, B, C, D be a number of line-vectors of which B is applied at the end of A, C at the end of B, D at the end of C (fig. 8). Let this complex be denoted by $\mathfrak{R}$ and the common resultant by R. As the complex is a broken line with its parts in a definite order, but the resultant merely a straight line from the initial point to the final point, the powers of the complex are very different from those of the resultant. Nothing but confusion results from not distinguishing between the complex and the resultant. We have seen this already in expanding a complex logarithm.

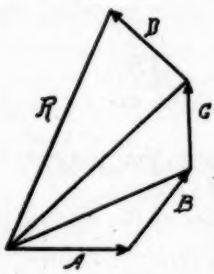

Fig. 8.

Let $\mathfrak{R} = A + B + C + D$. The square of $\mathfrak{R}$ is the algebraic square of the quadrinomial, with the proviso that the natural order of the vectors be preserved in each term; that is A prior to B, B prior to C, C prior to D. Hence

$$\begin{aligned}\mathfrak{R}^2 = {} & A^2 + B^2 + C^2 + D^2 \\ & + 2\ \{AB + AC + AD \\ & \qquad + BC + BD \\ & \qquad\quad + CD\}\end{aligned}$$

and the same is true for any number of terms. Let the sum of the scalar terms be denoted by Cos $\mathfrak{R}^2$; then

$$\begin{aligned}\text{Cos}\ \mathfrak{R}^2 = {} & A^2 + B^2 + C^2 + D^2 \\ & + 2\text{Cos}\ \{AB + AC + AD\} \\ & \quad + 2\ \text{Cos}\ \{BC + BD\} \\ & \qquad + 2\ \text{Cos}\ CD\end{aligned}$$

which gives the square of the resultant.

But there is a complementary part which may be denoted by Sin $\mathfrak{R}^2$; and it is

$$2 \text{ Sin } \{AB + AC + AD\} + 2 \text{ Sin } \{BC + BD\} + 2 \text{ Sin } CD$$

This vector part by reading the columns is seen to be 4 times the directed area of the triangles AB, $(A+B)\,C$, $(A+B+C)\,D$; and the resultant is 4 times the maximum projection of these areas.

The third power of the complex is formed after the same algebraic principle, giving, for a trinomial,

$$\mathfrak{R}^3 = A^3 + B^3 + C^3 + 3\{A^2B + A^2C + B^2C\} + 3\{AB^2 + AC^2 + BC^2\} + 6ABC.$$

The conjugate third power is much more complex, viz:

$$\begin{aligned}\mathfrak{R}\mathfrak{R}\mathfrak{R} = {} & A^3 + B^3 + C^3 \\ & + A^2B + A^2C + B^2C + AB^2 + AC^2 + BC^2 \\ & + BA^2 + CA^2 + CB^2 + B^2A + C^2A + C^2B \\ & + ABA + ACA + BCB + BAB + CAC + CBC \\ & + ABC + ACB + BCA + BAC + CAB + CBA\end{aligned}$$

The last six terms form a determinant in vectors.

Cyclic complex of vectors. In a cyclic complex the vectors have a common point of application, and the order is determined by the order in which the free extremities occur in a cycle. Let R denote such a complex; for example $R = A + B + C$ (fig. 9). The square is formed from the algebraic square by inserting cyclic order: thus

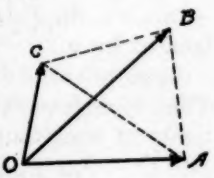

Fig 9.

$$R^2 = A^2 + B^2 + C^2 + 2\,AB + 2BC + 2\,CA.$$

This differs from the corresponding line complex in having CA instead of AC. Hence

$$\text{Cos } R^2 = A^2 + B^2 + C^2 + 2 \text{ Cos } AB + 2 \text{ Cos } BC + 2 \text{ Cos } CA.$$

So far as unit is concerned, these terms break up into the three pairs

$$A^2 + 2 \text{ Cos } AB, \qquad B^2 + 2 \text{ Cos } BC, \qquad C^2 + 2 \text{ Cos } CA.$$

Again Sin $R^2 = 2$ Sin $AB + 2$ Sin $BC + 2$ Sin CA that is, four times the directed areas of the three faces; the resultant of which is equal and opposite to the directed area of the fourth face ABC.

The Cartesian coördinates involve a cyclic complex. For example $R = xh + yj + zk$; the square of which is

$$R^2 = x^2h^2 + y^2j^2 + z^2k^2 + 2\,xy\,.\,hj + 2\,yz\,.\,jk + 2\,zx\,.\,kh.$$

Application to dyadic Φ. A dyadic is a sum of dyad quotients $L/A + M/B + N/C$, of which the antecedents A, B, C, are cyclic, as also the consequents L, M, N. Hence the dyadic is a cyclic complex of dyads, and may be treated as a cyclic complex. For example, the direct square of Φ (not the one commonly treated which is formed after the conjugate multiplication) is

$$\Phi^2 = L^2/A^2 + M^2/B^2 + N^2/C^2 + 2\,LM/AB + 2MN/BC + 2NL/CA.$$

Hence Cos $\Phi^2 = L^2/A^2 + M^2/B^2 + N^2/C^2$
$+ 2\text{Cos}\,LM/\text{Cos}\,AB + 2\,\text{Cos}\,MN/\text{Cos}\,BC + 2\,\text{Cos}\,NL/\text{Cos}\,CA$

And $\frac{1}{2}$ Sin Φ^2 = Sin LM/Sin AB + Sin MN/Sin BC + Sin NL/Sin CA, and this last is the invariant commonly designated by Φ_2.

Application to delta. Suppose f to be a function of r, θ, φ. Then ∇f may be defined as the cyclic complex formed of the quotients of simultaneous differentials, namely

$$\nabla f = \partial_r f/\partial_r R + \partial_\theta f/\partial_\theta R + \partial_\varphi f/\partial_\varphi R;$$

$$= \partial_r f/\partial r\,\rho + \partial_\theta f/r\frac{\partial\rho}{\partial\theta}\partial\theta + \partial_\varphi f/r\frac{\partial\rho}{\partial\varphi}\partial\varphi$$

$$= \frac{\partial f}{\partial r}/\rho + \frac{\partial f}{\partial\theta}/r\frac{\partial\rho}{\partial\theta} + \frac{\partial f}{\partial\varphi}/r\frac{\partial\rho}{\partial\varphi}.$$

Hence this expression is simply a dyadic in differentials.

The complete square of ∇. According to the result obtained in the previous paper

$$\nabla^2 = \frac{\partial^2}{\partial x^2}/h^2 + \frac{\partial^2}{\partial y^2}/j^2 + \frac{\partial^2}{\partial z^2}/k^2$$

$$+2\frac{\partial^2}{\partial x\partial y}/hj+2\frac{\partial^2}{\partial y\partial z}/jk+2\frac{\partial^2}{\partial z\partial x}/kh.$$

But this supposes that $h\ j\ k$ are constant. When they are variable we have the additional terms

$$\frac{\partial}{\partial x}/h^2\times\left\{\frac{\partial h}{\partial x}\frac{1}{h}+\frac{\partial h}{\partial y}\frac{1}{j}+\frac{\partial h}{\partial z}\frac{1}{k}\right\}$$
$$+\frac{\partial}{\partial y}/j^2\times\left\{\frac{\partial j}{\partial x}\frac{1}{h}+\frac{\partial j}{\partial y}\frac{1}{j}+\frac{\partial j}{\partial z}\frac{1}{k}\right\}$$
$$+\frac{\partial}{\partial z}/k^2\times\left\{\frac{\partial k}{\partial x}\frac{1}{h}+\frac{\partial k}{\partial y}\frac{1}{j}+\frac{\partial k}{\partial z}\frac{1}{k}\right\}$$

This formula still applies when the antecedent units have a modulus attached, as in the case of spherical coördinates.

Axial units. The principle that a parallelogram is equal to the scalar product plus the orthogonal product when applied to two line units α and β may be written

$$\alpha\beta=\cos\ \alpha\beta\ .\ \alpha^2+\sin\ \alpha\beta\ .\ \alpha\ [\alpha\beta]^{\pi/2}\alpha$$

By dropping the alphas in the latter term, and supposing the dimensions placed in the axis $[\alpha\beta]$ we pass to the corresponding axial unit, and write

$$\alpha\beta=\cos\alpha\beta\ .\ \alpha^2+\sin\alpha\beta\ .\ [\alpha\beta]^{\pi/2}$$

The index $\pi/2$ remains, or, what means the same thing, an i is attached to $[\alpha\beta]$ as $i\ [\alpha\beta]$. Consider next the unit $\alpha\beta\gamma$. We have

$$\begin{aligned}\alpha\beta\gamma&=\{\cos\ \alpha\beta\ .\ \alpha^2+\sin\ \alpha\beta\ .\ i\ [\alpha\beta]\}\ \gamma\\&=\cos\ \alpha\beta\ .\ \alpha^2\gamma+i\sin\alpha\beta\cos[\alpha\beta]\gamma\ .\ [\alpha\beta]^{3/2}\\&\quad-\sin\alpha\beta\sin[\alpha\beta]\gamma\ .\ [[\alpha\beta]\gamma].\end{aligned}$$

The second term has a scalar unit, but it is different in kind from α^2; because $[\alpha\beta]$ has two dimensions and the projection of γ along it only one. Hence the unit is $[\alpha\beta]^{3/2}$. It also involves an i. The third term reduces to

$$-\cos\ \gamma\alpha\ .\ \gamma^2\beta+\cos\ \beta\gamma\ .\ \beta^2\alpha;\ \text{hence}$$
$$\begin{aligned}\alpha\beta\gamma&=\cos\ \alpha\beta\ .\ \alpha^2\gamma-\cos\ \gamma\alpha\ .\ \gamma^2\beta+\cos\ \beta\gamma\ .\ \beta^2\alpha\\&\quad+\sin\alpha\beta\cos[\alpha\beta]\gamma\ .\ i\ [\alpha\beta]^{3/2}\end{aligned}$$

an equation which satisfies the principle of dimensions.

METEOROLOGY.—*The dense haze of June 10–11, 1912.* H. H. KIMBALL. To appear in full in the Bulletin of the Mount Weather Observatory.

General meteorological conditions. From June 8 to 12, 1912, the atmospheric conditions at Mount Weather were dominated by an area of high pressure that slowly advanced during the five days from the upper Mississippi valley to the South Atlantic Coast, and was nearly central over Mount Weather on the 10th and 11th.

Temperature and humidity conditions. Kite observations show that a decided fall in temperature occurred on the 7th and 8th, which extended to a height of at least 3 kilometers above sea level; and that the low temperature of the 8th was accompanied by a low water vapor content of the atmosphere. On the 9th the temperature of the air up to a height of at least 3 kilometers was rising. There was not sufficient surface wind for kite flights on the 10th and 11th, but the flight on the 12th showed considerably higher temperatures than on the 9th to a height of at least 4 kilometers, and also a considerable increase in the absolute humidity of the atmosphere.

Haze and clouds. On the 8th and 9th the atmosphere was unusually clear for June, but cumulus clouds formed before oon non both days. There were practically no clouds from the morning of the 10th to noon of the 11th, and the lower atmosphere was still clear, so that mountains 30 miles distant were distinctly visible; but the upper atmosphere was filled with a dense white haze. A cirrus cloud sheet covered the sky during the afternoon of the 11th. On the morning of the 12th the haze in the upper atmosphere had become light, but in the lower atmosphere it was dense, so that mountains 16 miles distant were completely obscured. Clouds covered the sky before noon.

Pyrheliometer observations. From pyrheliometric measurements of the intensity of solar radiation it appears that the atmospheric transmission coefficient, a, decreased in value from 0.756 shortly before noon of the 9th to 0.586 at the same hour on the 10th. Its value increased to 0.751 at 5.10 p.m. on the 10th, but was

very low during the morning of the 11th, and markedly higher again on the morning of the 12th.

On the 8th and 9th, shortly before noon, the radiation received diffusely from the whole sky was about 10 per cent of the vertical component of direct solar radiation, while on the 10th at about the same hour it was 30 per cent of this component.

Sky polarization observations. Measurements with a Pickering polarimeter of the polarization of sky light at the point of maximum show that the polarization decreased from 67 per cent at 9 a.m. of the 9th to 14 per cent just before noon of the 10th. It increased to 42 per cent at 5.10 p.m., and to 64 per cent at sunset, on the 10th, but was low during the morning of the 11th, and again higher on the morning of the 12th.

Measurements of the anti-solar and the solar distances of the neutral points of Arago and Babinet, respectively, showed a slight increase in the anti-solar distance of Arago's point of the 10th as compared with the 8th, while the increase in the solar distance of Babinet's point was more than two degrees.

Conclusions. The decrease in the percentage of polarization of skylight, and in the value of the atmospheric transmission coefficient, a, between June 9 and 10, and also the increase in the solar distance of Babinet's neutral point between June 8 and 10, are attributed to the increased haziness of the atmosphere on the latter date.

While increased haziness at the center or in the rear of an area of high pressure is a common occurence at Mount Weather, the haze of June 10 and 11 was of unusual density. The winds thruout the five-day period, June 8 to 12, were generally from some point between north and west, and were light on the 10th and 11th. We must therefore attribute the increased haziness of these two days to processes taking place in the atmosphere, rather than to changes in the constituents of the atmosphere due to air currents from a direction differing from that which had prevailed.

The most active process during this period appears to have been convection, which must have carried considerable quantities of dust and moisture from the surface to at least the top of the cumulus cloud layer, or to about 3 kilometers above sea level.

On account of the light winds that prevailed, both dust and moisture accumulated in the atmosphere on the 10th and 11th, but were swept away by the higher winds of the 12th.

In addition, innumerable little whirls would be established in a body of stagnant air that was being heated rapidly and unequally from point to point on account of variations in the character of the surface below. At the boundary surfaces of these whirls heat and light waves would be both reflected and refracted, whereby adding to the haziness attributable directly to dust or moisture particles. These whirls would be most numerous at the time of the most rapid rise in temperature, or from shortly after sunrise to shortly before noon, and would cease before sunset. The air would also be relatively drier in the afternoon than in the morning, on account of its increased temperature, and in consequence the dust particles would have less hazing effect.

It appears, therefore, that the dense haze of June 10 to 11, 1912, may be attributed to the effects of convection in quiescent air prevailing at the center of a nearly stationary center of high pressure, and that the unusual diurnal variation in atmospheric transparency on the 10th was the result of diurnal temperature changes.

A rapid diminition in the solar distance of Babinet's neutral point occurred on both the 8th and 10th when the sun was about 3 degrees below the horizon, being especially well marked on the 10th. It therefore seems probable that the upper limit of the haze on the 10th was at about the height of the top of the cumulus cloud layers of the two preceding days, or approximately at 3 kilometers above sea level. This conclusion is in accord with the results of recent studies by Suring and Humphreys.[1]

PHYSICS.—*A new reflection ocular.* P. G. NUTTING, Bureau of Standards.

The reflecting ocular here described was devised as a substitute for the well known Gauss ocular to give increased illumination

[1] Humphreys, W. J., Dust layers in the atmosphere and changes in the neutral points of sky polarization. Bull. Mt. Weather Observ., **4**: 397.

and sensibility. The same device serves as a most excellent photometric ocular.

In the ordinary Gauss ocular, an unsilvered glass plate, set at an angle of 45° with the axis, throws light from the side forward along the axis. The cross hairs are illuminated by this beam passing forward while the field is illuminated by light reflected back from the objective. The reflected image of the cross hairs is a shadow on a bright ground, brightly or faintly illuminated according to the aperture of the reflected beam. The setting is a superposition of the hairs on their shadows, both on a moderately illuminated field, conditions unfavorable to high precision particularly if the reflected beam be narrow. The reflected image is further very difficult to pick up under unfavorable conditions.

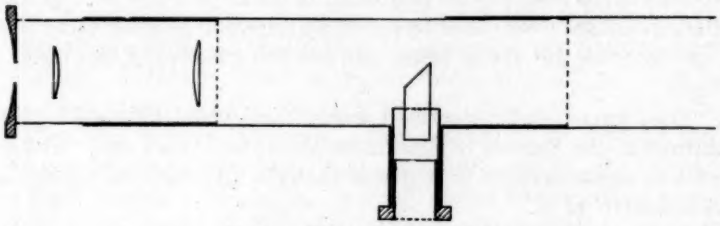

Fig. 1. New reflecting ocular

In the improved form of ocular, figure 1, a thin elongated reflecting prism is introduced in front of the ocular as shown in the diagram. This reflecting prism is of microscope cover glass 0.15 to 0.20 mm. thick, about 5 mm. wide, and 15 mm. long. Such prisms are easily prepared 50 at a time by grinding a pile of cover glasses clamped together. The sleeve into which the ocular slides is provided with a short side tube. Into this fits a metal plug with a knurled head, half the plug being cut away. To the remaining half the reflecting prism is attached with soft wax.

This ocular gives a brilliant reflected image easily seen in any part of the field of view. Owing to the smallness of the entering beam the field illumination is low. The setting is a superposition of the black rear face of the prism on its bright reflected image.

This setting can be made with a precision fully equal to that of the Gauss ocular under the most favorable conditions. When the plane surface to be set upon is but a few square millimeters and the Gauss ocular cannot be used at all, the new form gives excellent results.

The new ocular is used for photometry by simply rotating the reflecting prism 180° so that it faces toward the eye instead of the objective. Uniform illumination is secured by placing a fragment of opal glass over the outer end where the light enters. This arrangement has been used considerably at the Bureau of Standards in the measurement of diffuse reflection and transmission but it has not yet been tried on extra focal star images.

This thin form of reflecting prism has been used with great success in microscopes for illuminating the object viewed. It has the advantage over other forms of illumination of interfering but slightly with the visual beam and resolving power of the instrument.

The form of ocular described above was devised and used by the author at the Bureau of Standards about two years ago. It has proven so serviceable that it was thought advisable to publish a description of it.

GEOLOGY.—*Fall of volcanic ash on Seward Peninsula, Alaska, in 1907.* PHILIP S. SMITH.

The renewed interest in volcanic phenomena caused by the recent eruptions in southwestern Alaska warrants a statement concerning a fall of volcanic ash in Seward Peninsula in 1907, that has hitherto been unrecorded in scientific journals.

The ash is reported to have begun falling at Nome in the evening of November 24 and to have continued until the morning of November 28. The ash was reported from all parts of Seward Peninsula and even from places as far east as the Yukon. Samples were collected and have been preserved by the Geological Survey from the following localities: Nome, Solomon, Teller, Alder Creek in the Bluestone Basin, Lost River, York, Kingegan, Cheenik, Candle, Nulato, and Unalakleet. All of the material is dark

brown and very fine-grained. The largest grains in a specimen examined by Dr. Albert Johannsen are reported to have been from 0.02 mm. to 0.06 mm. in diameter. The material consists chiefly of fine volcanic glass but there are also a few grains that show polarization colors, tho they are too small for mineralogical identification. Dr. Johannsen reported that there is no magnetite in the ash collected near Nome but certain of the specimens from the western part of the peninsula, notably those from York and Lost River, show a little of this mineral.

The amount of ash that fell is variously estimated by different observers but many of the stories are evidently exaggerated and there seems to be no marked difference in quantity in the different parts of the region. The most trustworthy estimate was furnished by Arthur Gibson of Nome, who is the local observer for the Weather Bureau. He weighed the ash that collected in the official rain gage and found that 11 grains fell per square foot of surface. If this is correct, it follows that nearly 22 tons of ash fell on each square mile in the vicinity of Nome.

Nothing definite is known of the location of the volcano from which the ash came. Natives at Candle are said to have reported "Big mountain peluk (gone), smoke!" and to have signified a location to the north of Kotzebue. There are no recent volcanoes known in that region and considerable doubt is felt of the accuracy of this story. The records of the Weather Bureau at Nome show that the winds were prevailingly from the west and north during the shower. This suggests a Siberian or northwestern Alaskan location for the volcanic outburst, possibly in so sparsely inhabited a region that the eruption was not observed. The well-known difference in direction of upper and lower air currents, however, makes the wind direction an unsatisfactory criterion, especially as eruptions are known to have been in progress in the Bogoslof Islands to the south at least as late as October, 1907.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*The gabbros and associated rocks at Preston, Connecticut.* G. F. LOUGHLIN. Bulletin U. S. Geological Survey No. 492. 1912. Pp. 158, with maps and sections.

The Preston region, a quadrangular area of about 102 square miles, lies in the southeastern part of Connecticut, a few miles north of Stonington on Long Island Sound. The pre-glacial formations comprise metamorphic sedimentary rocks, gabbro and granite intrusions, and an immense mass of quartz. The metamorphic sedimentary rocks, assigned provisionally to the Cambrian and Carboniferous, include quartzite, quartz-biotite schist, hornblende schist, black pseudoporphyritic schist (kinzigite), and dolomite, all, so far as local evidence shows, conformable. The gabbro, comprising two principal and several minor varieties, forms a main mass of oval outline, a few outliers, and some intrusive sheets. The granite, comprising three varieties, is represented by numerous intrusive sheets.

In the schists derived from sedimentary rocks the schistosity, so far as observed, is coincident with original bedding. Major folds are not clearly marked, but overturned synclines are indicated in the eastern and western parts of the area. During folding the central gabbro mass acted, with respect to the schists, like a large resistant pebble in the relatively plastic matrix of a mashed conglomerate. The secondary strains induced by its deformation in conjunction with the primary folding of the region, tended to develop abnormal crumpling locally and were sufficient to determine the paths of the granite intrusions. The intrusion of this granite completed the local deformation.

Both the main mass and the outliers of the Preston gabbro appear to be sills. Consideration of the effects of regional metamorphism indi-

cates that the gabbro had been intruded and had cooled at the period of compression. The varieties of gabbro are probably due to magmatic segregation.

The chief varities of Sterling granite gneiss are normal granite occurring as a batholith, porphyritic and alaskite phases intruded as sills, and pegmatite dikes. The intrusion of the main masses was accompanied by a thoro granitic injection of the neighboring biotitic schist accompanied by some pneumatolysis.

The quartzite includes minor variations containing lime-magnesia silicates and labradorite. The quartz-biotite schist, with its hornblendic, calcareous, and feldspathic variations, is regarded as an altered arkosic sandstone. The hornblende schist, chemically similar to gabbro, is believed to be a metamorphosed basaltic tuff. The black pseudoporphyritic schist has the mineral composition of kinzigite, but differs from the type in its pseudophenocrysts of albite-oligoclase and garnet, and is interpreted as the metamorphic form of a previously altered basaltic tuff.

In the porphyritic gabbro the order of crystallization was (1) feldspar, (2) diallage accompanied or closely followed by ilmenite. Pyrite appears to be contemporaneous with magnetite. In the norite the order of crystallization was (1) bronzite, (2) labradorite, (3) diallage, (4) titaniferous magnetite and pyrite. The olivine gabbro crystallized similarly but with olivine in place of bronzite. The pyroxenite merely represents a segregation of the ferromagnesian portion of the gabbro magma and is cut by complementary dikes of plagioclase pegmatite. The gabbro outliers and amphibolite sheets are gradational between porphyritic and quartz-hornblende gabbro.

The conclusion is reached that the two principal varieties of the gabbro are due to an incomplete differentiation prior to crystallization but that the minor phases are due to local segregation.

The Sterling granite gneiss is fairly typical of gneissoid biotite granite in general. Study of the granulation of their feldspar and quartz indicates that the normal and porphyritic granites were intruded and crystallized during the height of the compression period, the alaskite during the closing stages, and the pegmatite in the alaskite after compression and movement had practically ceased. The time of intrusion is supposed to be that of the Appalachian revolution.

The Lantern Hill quartz in North Stonington is believed to represent replacement of alaskite by quartz during the pneumatolytic stage of granite intrusion.

The correlation of the granites of this area with those of the Narragansett Basin is a problem for the future. Shaler, Woodworth, and Foerste regard the granite of the Narragansett Basin as older than the Carboniferous sediments while the Sterling granite gneiss of the Preston area is intrusive into them. C. E. SIEBENTHAL.

GEOLOGY.—*Pawpaw-Hancock, Md., W. Va., Pa., folio.* G. W. STOSE and C. K. SWARTZ. Geologic Atlas of the United States, No. 179. 24 folio pp., with maps, views and sections. U. S. Geological Survey, Washington, D. C. 1912.

The rocks exposed in the area range from Cambrian to Carboniferous and comprise, from the base up, Conococheague limestone, Beekmantown limestone, (Stones River and Chambersburg limestones absent at surface by reason of faulting), Martinsburg shale, Juniata formation, Tuscarora formation, Clinton shale, McKenzie formation, Wills Creek shale, Tonoloway limestone, Helderberg limestone, Oriskany sandstone, Romney shale, Jennings formation, Catskill formation, Rockwood formation, Purslane sandstone, Hedges shale, Myers shale, Pinkerton sandstone.

The beds are rather strongly folded, the axes striking northeast-southwest, the Cambrian rocks appearing only at the southeastern corner of the area, the Carboniferous in three narrow synclinal bands. The folds are not as continuous as in most parts of the Appalachian province, many of them terminating in the area by plunging or branching. Many complete arches and synclines are exposed in stream banks and in artificial cuts, and are illustrated by half-tone cuts. In the eastern part of the area the folds are overturned, broken, and extensively overthrust.

The area is crossed from west to east by the Potomac River whose channel is deeply cut in the surrounding upland and is bordered by a series of gravel-covered terraces recording stages of uplift of the land. The highest gravels found are 250 feet above the river level. The upland is an early Tertiary planation surface on which were developed the great meanders of the Potomac. The Jurassic-Cretaceous peneplain is preserved only on the tops of the highest mountains. Changes in the drainage of the area are discussed.

The only products of economic importance in the area are glass sand from the Oriskany, extensively mined in the vicinity of Berkeley Springs, W. Va., and natural cement rock, formerly quarried at Roundtop, Md.

G. W. S.